Lighting Research and Development
Building Technologies Program
Office of Energy Efficiency and Renewable Energy
U.S. Department of Energy

April 2006

Solid-State Lighting Program Planning Workshop Report

February 1-3, 2006
Orlando, Florida

Prepared for:
Lighting Research and Development
Building Technologies Program
Office of Energy Efficiency and Renewable Energy
U.S. Department of Energy

April 2006

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COMMENTS

The Department of Energy is interested in feedback or comments on the materials presented in this Workshop Report. Please write directly to James Brodrick, Lighting R&D Manager:

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Solid-state lighting (SSL) technology leaders gathered in Orlando, Florida from February 1-3, 2006 to attend a workshop focused on advancing SSL technologies from the laboratory to the marketplace. Hosted by the U.S. Department of Energy (DOE) Office of Energy Efficiency and Renewable Energy (Building Technologies Program) and the Office of Science (Basic Energy Sciences Program), the purpose of the workshop was to provide a forum for exchange of information and ideas. More than 180 participants attended from industry, academia, trade associations, research institutions, and national laboratories.

Guided by a government-industry partnership, the mission of DOE's SSL program is to create a new, U.S.-led market for high-efficiency, general illumination products through the advancement of semiconductor technologies, to save energy, reduce costs, and enhance the quality of the lighted environment. The 2006 SSL workshop represented the third annual meeting of the Department's program to accelerate advances in SSL technology, and included for the first time a Basic Energy Sciences (BES) Contractors' Meeting. This format enabled BES and SSL researchers to exchange research highlights and results, identify needs, foster new ideas, and build relationships.

The Department's strategy for guiding SSL technology advances from laboratory to marketplace draws on its long-term relationships with the SSL industry and research community. DOE's comprehensive approach includes Basic Energy Science, Core Technology Research, Product Development, Commercialization Support, Standards Development, and an SSL Partnership.

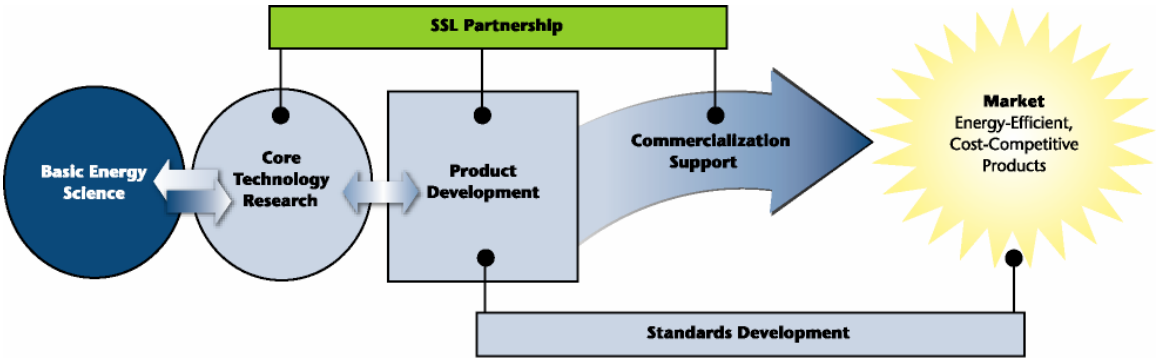

Figure 1-1: DOE Solid-State Lighting Portfolio

In recent decades, U.S. researchers have made substantial progress in improving the performance and lowering the cost of light-emitting diodes (LEDs) and organic light-emitting diodes (OLEDs). These advances have resulted in the development of niche and emerging applications for SSL technology, including landscape lighting, exit signs, traffic signals and airport runway edge-lights. SSL technology is poised to take a major role in the general illumination (i.e., white light) market. Government support of medium to longer-term R&D, aimed at improving SSL performance and lowering costs, will

continue to accelerate performance improvements and enable energy savings. At the same time, DOE support of targeted commercialization support activities will ensure that DOE research investments lead to technology commercialization.

Chapter 2 of this report outlines the presentations and activities from the BES Contractors' Meeting on Wednesday, February 1. Chapter 3 reviews the DOE SSL Program Updates and Project Presentations from Thursday, February 2. Chapter 4 summarizes updates on SSL Commercialization Support Activities presented on Friday, February 3. Finally, Chapter 5 describes several upcoming activities for the DOE SSL program.

2. Basic Energy Sciences Contractors' Meeting

The 2006 DOE SSL Workshop began on February 1, 2006, with a Basic Energy Sciences (BES) Contractors' Meeting. Sponsored by the Division of Materials Sciences and Engineering (DMS&E) in the DOE Office of Science, the meeting focused on BES/DMS&E-funded research that underpins solid-state lighting technology. This research cuts across several DMS&E program areas, and is designed to develop a fundamental scientific base for new concepts and materials.

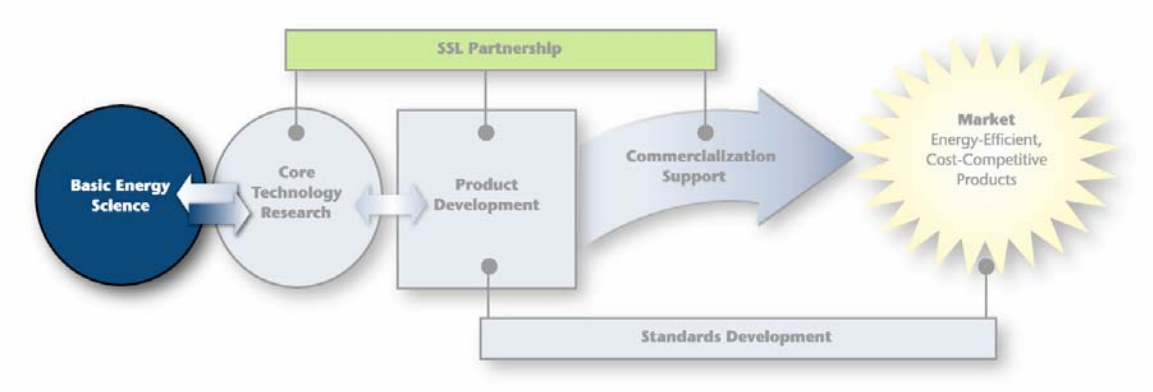

Figure 2-1: Day 1 Focus – BES Contractors' Meeting

The purpose of the BES Contractors' Meeting was to bring together researchers funded by BES in this emerging technology area, to facilitate the exchange of new results and research highlights, foster new ideas and collaborations among participants, and identify the needs of the research community. By combining the BES Contractors' Meeting with the annual DOE SSL Program Planning Workshop, DOE provided an opportunity for increased collaboration and information sharing between BES and SSL researchers.

2.1. Coordinated Efforts Advance Solid-State Lighting Research

To accelerate SSL technology developments, DOE leverages the strengths and capabilities of the Office of Science and the Office of Energy Efficiency and Renewable Energy (EERE). The BES program conducts basic research to advance fundamental understanding of materials behavior, with the goal of impacting future directions in applied research and technology development. EERE's SSL program guides technology advances from laboratory to marketplace with a comprehensive approach that includes Core Technology Research, Product Development, Commercialization Support, and Standards Development. Core Technology Research focuses on applied research for technology development, with the goal of meeting performance and cost targets. Through coordination and collaboration, these DOE research programs are working together to provide the scientific foundation for new forms of lighting.

2.2. BES Presentations Share Research Highlights and Results

BES Meeting Chair Valy Vardeny, University of Utah, began the day of presentations by introducing keynote speaker Stephen Forrest. Forrest, from the University of Michigan, spoke about electrophosphorescent OLED devices, and strategies for achieving high efficiency white light emission at high brightness for the next generation of SSL sources. The next speaker, Antoine Kahn from Princeton University, discussed recent progress on improving the interfaces of polymer electronic devices. Princeton is teaming with Georgia Institute of Technology, General Electric Global Research, and Cornell University on this project.

Valy Vardeny spoke on behalf of his collaborator Jing Shi, from the University of California at Riverside, on current efforts to exploit spin transport in organic semiconductors, to enhance the quantum efficiency of the light emission. Darryl Smith, from Los Alamos National Laboratory, presented on electron spin processes in solid-state organic electronic materials.

Arthur Ramirez provided an update on research conducted by Columbia University and Lucent Technologies, focused on improving the efficiency of OLEDs by controlling transport fundamentals in crystalline organic semiconductor devices. The next speaker, Michael McGehee, discussed recent progress at Stanford University to better understand the behavior of charges, excitons, and plasmons at organic and inorganic interfaces. Jean Frechet from Lawrence Berkeley National Laboratory provided an update on design, synthesis, and structuring of functional polymers and dendrimers with potential in SSL technologies.

Luncheon speaker Paul Alivisatos, from Lawrence Berkley National Laboratory, discussed how DOE Nanoscience Centers are poised to assist the SSL community in tackling a wide range of important issues. Alex Zunger from the National Renewable Energy Laboratory described the basic design rules for doping wide-gap materials, and some of the ways to potentially overcome self-limiting behavior. The next speaker, James Chelikowsky from the University of Texas, highlighted recent progress in examining the electronic structure of materials at the nanoscale and predicting optical properties.

Stephen Lee from Sandia National Laboratories discussed advances in understanding the luminescence, structure, and growth of wide-bandgap InGaN semiconductors. Costas Soukoulis from Ames Laboratory at Iowa State University provided a research update on negative refraction in metamaterials and the possible impact of metamaterials as optical elements. The next speaker, Paul Braun from the University of Illinois, described novel routes for creating 3D structures of high refractive index semiconductors. Wrapping up the day of presentations was Tom Russell from the University of Massachusetts, who focused on advances in biased self-assemblies in block copolymers and nanorods, which have promise for lighting applications.

2.3. Poster Session Provides Opportunity to Exchange Information and Build Relationships

In the evening, a BES Poster Session and Reception provided additional opportunities to share research results, identify needs, and build relationships. The following list details the poster topics and presenters. For more detailed information on the BES posters and presentations, download the 2006 BES Contractors' Meeting Abstract at: http://www.netl.doe.gov/ssl/PDFs/2006_Solid_State_Abstract_Book_FINAL.pdf.

Poster Session Topics and Presenters

Optical, Electrical, and Magnetic Studies of Ordered π-Conjugated Systems
Z. Valy Vardeny

The Organic Chemistry of Conducting Polymers: From Molecular Wires to Photovoltaics
Laren M. Tolbert and Janusz Kowalik

Combinatorial Fabrication and Screening of organic Light-Emitting Device Arrays
Joseph Shinar

Charge Injection and Transport in Polyflourenes
Alexis Papadimitratos, Hon Hang Fong, and George G. Malliaras

Spectroscopic Study on Sputtered PEDOT-PSS: Role of Surface PSS Layer
Jaehyung Hwang, Fabrice Amy, and Antoine Kahn

White-Light Emission from Ultra-Small Cadmium Selenide Nanocrystals
Michael J. Bowers II, James R. McBride, and Sandra J. Rosenthal

Enhanced Light Emission from Lu_2SiO_5 Induced by Ion Irradiation
Luiz G. Jacobsohn, Ross E. Muenchausen, and D. Wayne Cooke

Nanophosphors
Ross E. Muenchausen, Luiz G. Jacobsohn, and D. Wayne Cooke

In-Situ Synchotron X-Ray Studies of Metal Organic Chemical Vapor deposition of $In_xGa_{1-x}N$
G. Brian Stephenson, Fan Jiang, Stephen K. Streiffer, Anneli Munkholm

Luminescence, Structure, and Growth of Wide-Bandgap InGaN Semiconductors
S.R. Lee, D.D. Koleske, S.R. Kurtz, R.J. Kaplar, M.H. Crawford, D.M. Follstaedt, and A.J. Fischer

Overcoming Doping Bottlenecks in Semiconductors and Wide-Gap Materials
Shengbai Zhang and Su-Huai Wei

Theoretical and Experimental Study of Solid Composition and Ordering in III/V Systems
G.B. Stringfellow, F. Liu, A. Howard, and J. Zhu

Many Body Effects in Nanotubes Fluorescence Spectroscopy
E.J. Mele and L.C. Kane

Solid-State MAS NMR Studies of Supramolecular Zinc Chelates and ZnO Nanorods
Linda Sapochak, Li-Qiong Wang, Kim Ferris, Chunhua Yao, Greg Exarhos

Theoretical Investigations of Nanoscale Structures and Semiconductor Surfaces
J. Bernholc and C. Roland

Theory of Surface and Interface Properties of Correlated Electron Materials
Andrew Millis and Satoshi Okamoto

Metal-Insulator-Semiconductor Photonic Crystal Fibers: A New Paradigm for Optoelectronics
Y. Fink and J.D. Joannopoulos

Three-Dimensional Photonic Crystals by Soft Lithographic Technique
Jae-Hwang Lee, Yong-Sung Kim, Joong-Mok Park, Wai-Y. Leung, Chang-Hwan Kim, Ping Kuang, Rana Biswas, Kristen Constant, Kai-Ming Ho

3. DOE Program Updates and Project Presentations

The second day of the DOE SSL workshop focused on DOE program updates and project presentations. Presenters provided updates on the strategy and structure of the DOE SSL program, status reports on all DOE-funded SSL R&D projects, and an update on DOE's SSL partnership with the Next Generation Lighting Industry Alliance (NGLIA). To download the presentations detailed in this section, visit the Publications section of the DOE SSL website at: http://www.netl.doe.gov/ssl/materials_2006.html.

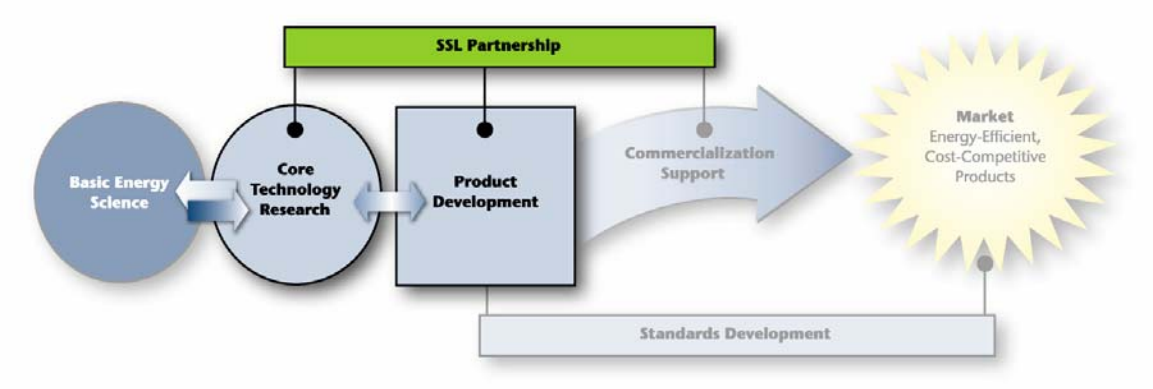

Figure 3-1: Day 2 Focus – DOE Program Updates and Project Presentations

3.1. Program Overview: Update on Program Progress

James Brodrick, U.S. Department of Energy

James Brodrick, SSL Program Manager, provided an overview and update on the SSL program. Guided by a government-industry partnership, the program's mission is to create a new market for high-efficiency, general illumination products through the advancement of semiconductor technologies, to save energy and enhance the quality of the lighted environment. Brodrick described the Department's comprehensive strategy:

- The **Basic Energy Sciences** program conducts basic research to advance fundamental understanding of materials behavior. Project results often have multiple applications, including SSL.
- **Core Technology Research** projects focus on applied research for SSL technology development, with particular emphasis on meeting efficiency, performance, and cost targets.
- **Product Development** projects focus on using the knowledge gained from basic or applied research to develop or improve commercially viable materials, devices, or systems.
- **Commercialization Support** activities, such as the development of ENERGY STAR® criteria for SSL products, are designed to ensure that DOE R&D investments lead to SSL technology commercialization.
- **Standards Development** activities include coordinated actions with national and international standards generating organizations.

- **SSL Partnership** activities enhance the manufacturing and commercialization focus of the DOE SSL program.

Brodrick outlined the Domenici-Barton Energy Policy Act of 2005 (Section 912), which directs DOE to carry out a Next Generation Lighting Initiative to support research, development, demonstration, and commercial application activities related to SSL. He then provided an overview of DOE SSL project funding to date. To download the complete Program Overview presentation, see: http://www.netl.doe.gov/ssl/PDFs/Brodrick%20Overview%201.27.pdf.

The current contract value of DOE SSL R&D projects is $51.7 million. This value includes DOE funding ($39.6 million) and applicant cost-share ($12.2 million). The total value is divided into 14 OLED projects for $24.8 million, and 21 LED projects receiving $26.9 million. The Department funds solid-state lighting research in partnership with industry (38% to large corporations, 32% to small businesses), universities (18%), and national labs (12%). Brodrick provided further breakdown, indicating that funding for 29 Core Technology projects equals $34.7 million; 6 Product Development projects are funded by $17.1 million.

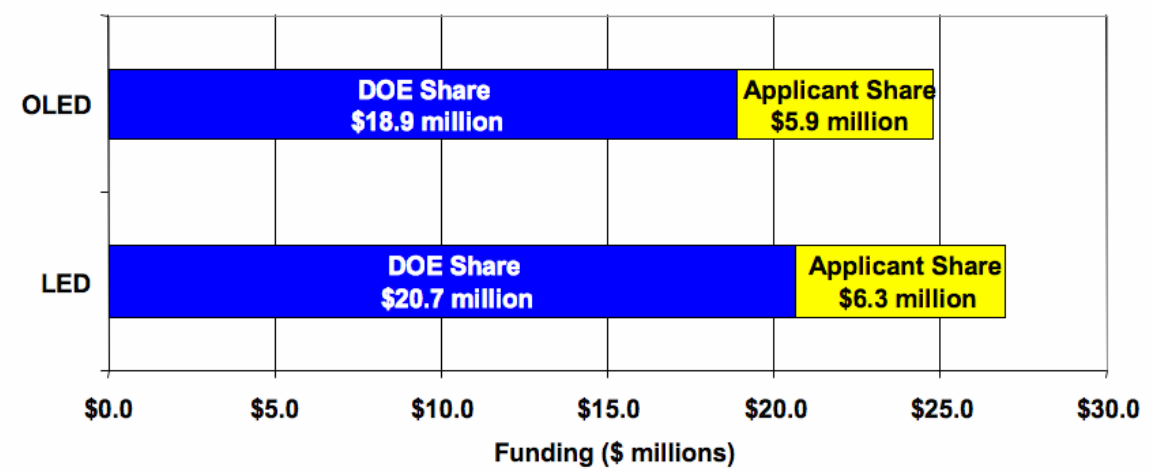

Figure 3-2: Current Contract Value of DOE SSL R&D Projects

A closer look at the 21 LED projects reveals that 17 involve research with Gallium Nitride (GaN) materials systems, and 4 involve work with other material systems. Of the 21 LED projects, 4 are studying multi-color systems, 11 are researching pc-LED systems, and 6 are studying technologies that could apply to either method of creating white light.

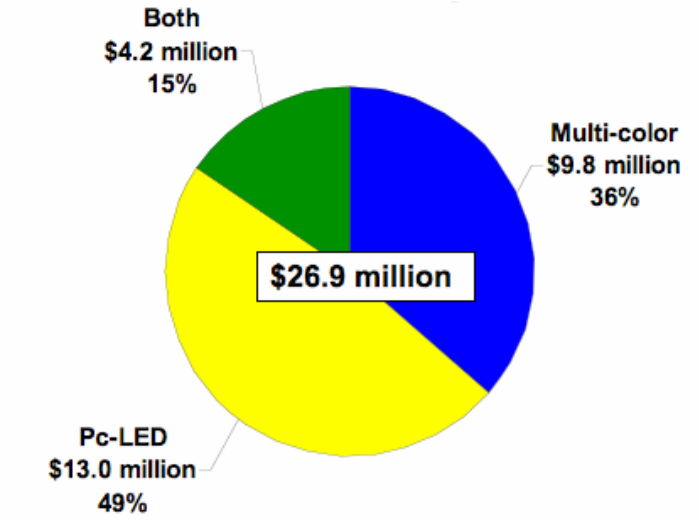

Figure 3-3: Methods for Creating White Light

Of the 14 OLED projects, 12 projects are researching small molecule OLEDs, one is researching polymer OLEDs and one could apply to either OLED material system.

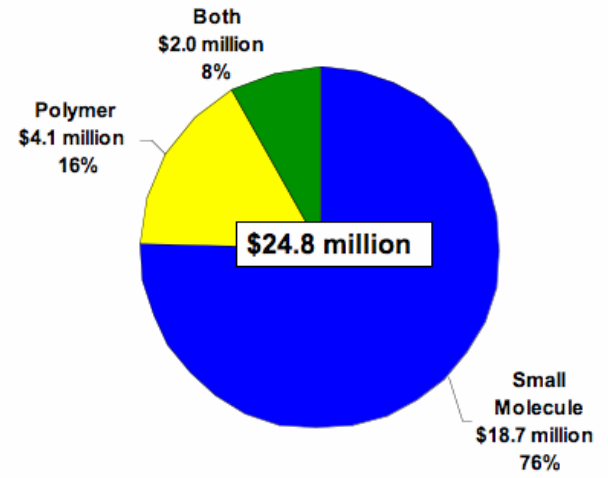

Figure 3-4: OLED Material Systems

Brodrick concluded with a review of research highlights from 2005, including new milestones in white light efficacy targets. Cree met the DOE FY05 white LED efficacy Joule Target of 65 lm/W with a novel chip design using a pre-production prototype. OSRAM achieved a record efficiency of 25 lm/W with a polymer-based white OLED. Researchers at the University of California at Santa Barbara advanced LED chip design, while the team at Lumileds, University of New Mexico, and Sandia National Laboratories demonstrated a large-area photonic crystal LED. Rensselaer Polytechnic Institute developed a silicone-based LED encapsulant that was licensed and supported with further research and market introduction.

Brodrick noted the record number of patents submitted as a result of DOE-funded research in 2005, an indication of the value of DOE projects to industry and notable progress toward commercialization. For more information on SSL patents resulting from DOE-funded research, download the Solid-State Lighting Patents handout at: http://www.netl.doe.gov/ssl/PDFs/SSL_PatentsFactSheet_v4.pdf.

3.2. Program Organization: Structure, Procedure, and Procurement Updates

C. Edward Christy, National Energy Technology Laboratory

C. Edward Christy of the National Energy Technology Laboratory reviewed the SSL program structure, procedures, and gave an update on recent and upcoming procurements.

Christy began by reviewing the guiding principles of DOE's SSL R&D program, including the emphasis on competition and shared cost and risk, the involvement of partners in planning and funding, the focus on targeted research for focused needs, and the use of innovative intellectual property provisions and an open process. Program success is largely determined by milestones met and ultimately by the amount and quality of energy efficient, long-life and cost-competitive products developed.

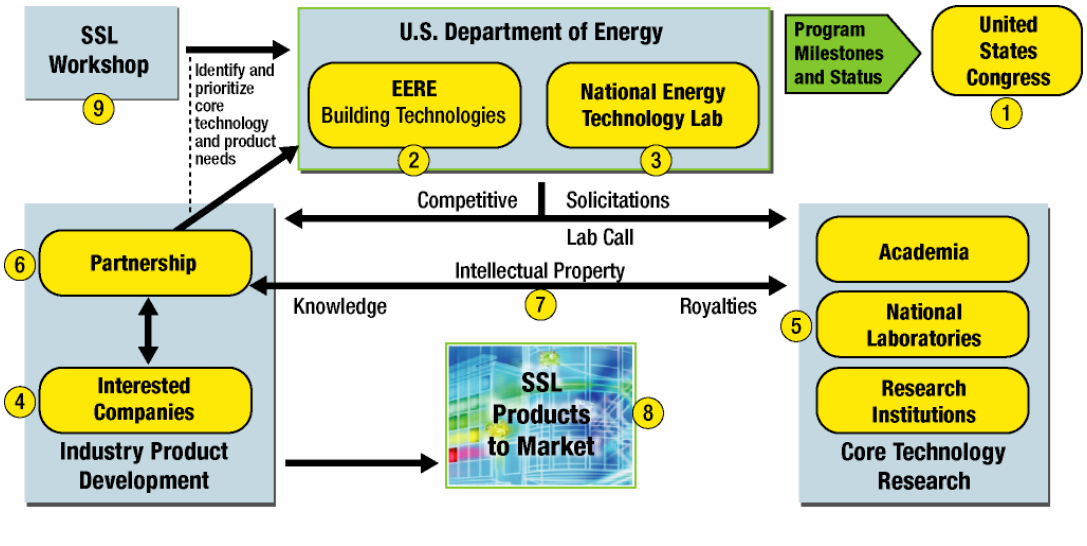

Figure 3-5: Structure of SSL Operational Plan

Christy outlined the components of the SSL operational plan, highlighting key updates from 2005:

1. United States Congress – Issues appropriations and language that "authorizes" the DOE to perform research and development, and requires reporting on program developments. In 2005, Congress passed EPACT 2005, directing DOE to carry out a Next Generation Lighting Initiative. Key points of the legislation include: authorization for $50 million from FY2007 through FY2013; direction to competitively select an industry alliance and award competitive R&D projects;

direction to implement intellectual property guidance, and to make roadmaps and information available to the public.

2. EERE/Building Technologies – Serves as program lead for activities, performs strategic planning, defines program, and interfaces with Congress.
3. National Energy Technology Laboratory – Develops and issues solicitations, manages selected projects, and reports on project status to DOE HQ.
4. Interested Companies – Submit applications that require a plan describing the development of marketable SSL products.
5. Core Technology Research – Collection of projects performed by national laboratories (Lab Call) and academic and research institutions. This research focuses on the earlier stages of SSL development (barrier issues).
6. SSL Partnership – Provides input to and prioritization of the Core Technology Research program needs; provides administrative expertise and staffing to organize and conduct technical meetings and workshops; supports demonstrations of SSL; provides, at DOE's discretion, technical reviews of Core Technology Research projects; and encourages efforts to develop SSL metrics and standards. For more information, download the SSL Partnership Update presentation at: http://www.netl.doe.gov/ssl/PDFs/Work_Partnership_Workshop06.pdf.
7. Intellectual Property – This component ensures that energy-efficient technologies are introduced to the market quickly to maximize energy savings benefits to the nation. In 2005, DOE issued an Exceptional Circumstances Determination for new patented inventions made under the Core Technology program area. Core Technology program awardees must make intellectual property generated as a result of DOE-funded research available for nonexclusive licensing to members of the DOE SSL Partnership, for one year following patent issue. This novel management approach will facilitate more rapid commercialization of SSL technologies. To download a PDF copy of the Determination, see: http://www.netl.doe.gov/ssl/PDFs/ECD%20Announcement%20-%20040614.pdf.
8. SSL Products to Market – This component leverages programs that can help raise awareness, improve accessibility, and encourage acceptance of new SSL products introduced to the market.
9. SSL Workshop – The annual stakeholder workshop provides a forum for sharing information on the DOE SSL program and progress, project updates, and developments in commercialization support activities.

Christy concluded by detailing the planned schedule for solicitations in 2006. Round 2 of lab and industry Core Technology solicitations are scheduled to be selected in Winter 2006, with awards anticipated in Spring/Summer 2006. Applications for Round 2 of the Product Development solicitation were received in January, 2006, with selections expected in early Spring 2006, and awards anticipated in the Summer of 2006.

Round 3 lab and industry Core Technology solicitations will be issued in Spring 2006, with awards anticipated in FY 2007. Round 3 of the Product Development solicitation is slated for Spring/Summer 2006 with awards in FY 2007. The SSL Nanoscience Technology solicitations will be issued in Spring 2006.

3.3. SSL Partnership Update

Dale Work, Next Generation Lighting Industry Alliance

Dale Work from Philips Lighting provided an update on DOE's SSL Partnership with the Next Generation Lighting Alliance (NGLIA). NGLIA is an alliance of for-profit corporations formed to accelerate solid-state lighting development and commercialization through government-industry partnership. Administered by the National Electrical Manufacturers Association (NEMA), members include: 3M, Acuity Brands Lighting, Air Products & Chemicals Inc., CAO Group Inc., Color Kinetics Inc., Corning Inc., Cree Inc., Dow Corning Corporation, Eastman Kodak Company, General Electric Company, GELcore LLC, Light Prescriptions Innovators LLC, Lumileds, OSRAM Opto Semiconductors Inc., OSRAM Sylvania Inc., and Philips Electronics North America Corporation. Since early 2005, the Alliance has grown by six new members.

The Alliance holds bi-monthly meetings with DOE and works on a wide range of activities. Dale Work described current efforts, aligned with EPACT directives, to identify SSL technology needs from an industry perspective, assess progress of research activities, and assist in annual updates of SSL technology roadmaps. He also detailed how the Alliance supports the implementation of DOE's Multi-Year Program Plan for SSL R&D, providing input on draft DOE ENERGY STAR criteria for SSL products, a study of lessons learned with compact fluorescent lighting (CFLs), the Lighting for Tomorrow design competition, and technology procurement of SSL products.

Outside of the DOE partnership, the Alliance works to carry the message of technology and energy saving potential to government, and provides a forum for SSL communication among for-profit companies. For more information, download the SSL Partnership Update presentation at:
http://www.netl.doe.gov/ssl/PDFs/Work_Partnership_Workshop06.pdf.

For information on joining the Alliance, visit the NGLIA website at: www.nglia.org.

3.4. Update on Basic Energy Sciences Program

Tim Fitzsimmons, U.S. Department of Energy

Tim Fitzsimmons of the Office of Basic Energy Sciences provided an update on the scientific research underlying SSL. The mission of the Basic Energy Sciences program is to advance the frontiers of knowledge to provide the scientific foundations for new and improved, environmentally conscientious energy technologies, to create and operate forefront scientific user facilities, and to provide innovative and effective research teams and tools.

Fitzsimmons described how nanoscale basic research presents new opportunities to advance SSL technologies. Recent LED research advancements and opportunities have come from new materials, photon creation, photon extraction, and photon wavelength conversion. Nanotechnology-enabled LED research has resulted in breakthroughs in several areas, including nanoscale substrate patterning, which reduces GaN defects by

100 times; 2-3 nm InGaN quantum well structure; nano quantum dots as phosphors; and photonic crystal LEDs. Nanoscale research opportunities in OLEDs are centered on organic semiconductors, synthesis and processing, and nanoscale manipulation.

Fitzsimmons then described the BES national user facilities for nanoscale science, which focus on the synthesis, characterization, and study of nanoscale materials.

- Center for Nanoscale Materials (Argonne National Laboratory)
- Center for Functional Nanomaterials (Brookhaven National Laboratory)
- Molecular Foundry (Lawrence Berkeley National Laboratory)
- Center for Nanoscale Materials Sciences (Oak Ridge National Laboratory)
- Center for Integrated Nanotechnologies (Sandia & Los Alamos National Labs)

Attendees were encouraged to examine the use of BES research and knowledge, and to explore interaction with the nanoscience centers for assistance with research and development activities.

3.5. Keynote Presentation: A History and Overview of the International Technology Roadmap for Semiconductors (ITRS)

Alan Allan, ITRS

Alan Allan from Intel Corporation provided a brief history of the International Technology Roadmap for Semiconductors, highlighting trends and parallels to the SSL technology roadmap. The ITRS' mission is to coordinate among associations and industry members, and create policies and goals that will take semiconductors from strategy to implementation. The organization recognizes trends, including the need for globalization, and drivers similar to those in today's lighting industry.

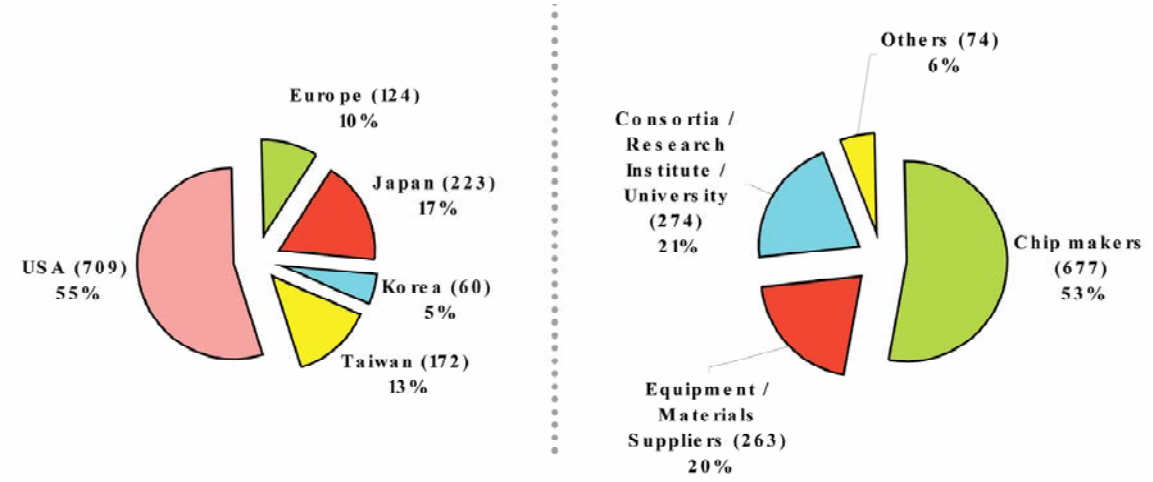

Figure 3-6: ITRS Global Demographics

Allan described the ITRS goals to present an industry-wide consensus on the "best current estimate" of future R&D needs out to a 15-year horizon, and provide a guide for the efforts of research organizations/sponsors (industry, government, and universities).

These goals are based on the premise of continuing the four-decade-long trends of an industry that distinguished itself by rapid pace of product improvements, exponential improvement of manufacturing capability and productivity to reduce the minimum feature sizes, and cost/function used to fabricate integrated circuits.

Allan discussed how the ITRS is used as a global planning tool to address issues like technology pacing, lithography front end processes/PIDS, economic trends, and overcoming challenges in scaling conductors and inter-metal dielectrics.

The history of this industry's process and progress parallels many of the issues and challenges facing the lighting industry. Allan concluded by providing a recap of ITRS areas of focus for 2005 and beyond, emphasizing that global roadmap consensus building and R&D support are essential elements for guiding industry progress.

3.6. Luncheon Presentation: SSL R&D in Key Countries – Investments, Patents, and Publications

Mark Huey, Strategic Perspectives, Inc.

Mark Huey of Strategic Perspectives, Inc., provided international context for the SSL market. Huey presented a study that quantifies the relative position of U.S. and international SSL investments and R&D activity. His findings point to 2006-2007 as a pivotal period for SSL research and U.S. national competitiveness.

The purpose of the DOE-funded project was to raise the level of common understanding in DOE and U.S. industry with respect to international strengths, to add rigor to conventional wisdom, and to provide a baseline for future comparisons. Major project activities included the analysis of the U.S. competitive position in terms of inputs (i.e., R&D $) and outputs (i.e., patents, publications), and the assessment of whether other countries are putting a higher priority on SSL.

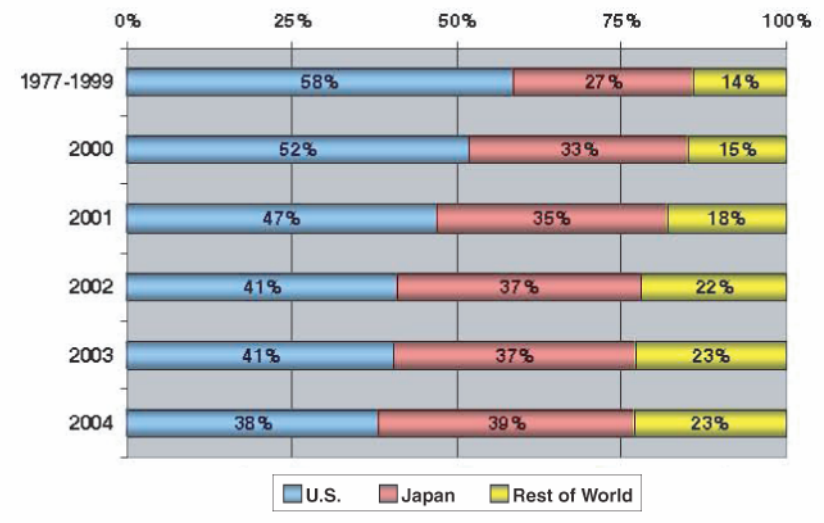

Figure 3-7: Share of U.S. SSL Patents

Key findings indicate that investment levels in the U.S. are worrisome. Although U.S. research capacity is still world-leading, Huey's tracking of research indicators (patents and publications) raises cause for concern when compared to other countries. Trends in the chart above indicate a decline in the U.S. share of SSL patents in the last five years. Specific research activity within particular topics is equally alarming.

Huey concluded by suggesting various ways the SSL community can use this information. A comparison can be made by reviewing the topics that have recently peaked and those that are about to emerge. For competitive reasons, R&D organizations can work to understand which overseas researchers, institutes, and companies are active in their field, and try to obtain a picture of their portfolio position relative to others. Knowing which overseas companies are moving towards their patent portfolio can assist with strategic decisions moving forward. To download the complete International SSL R&D presentation, see: http://www.netl.doe.gov/ssl/PDFs/Huey_International%20Perspective.pdf.

3.7. Presentations on SSL Projects in the DOE R&D Portfolio

Day 2 of the Workshop also included brief presentations on current DOE-funded SSL projects. Presenters for each of the current projects provided an overview of the project team, R&D objectives, project elements, and technology. These presentations provided attendees with a snapshot of DOE's current project portfolio and progress. These presentations were run in two concurrent sessions – one consisting of the LED Project Reports (21 projects) and another for OLED Project Reports (14 projects).

To see an overview of all current DOE-funded R&D projects related to SSL, including a brief description, partners, funding level, and proposed timeline, see the 2006 SSL Project Portfolio in the Publications section of the DOE SSL website at: http://www.netl.doe.gov/ssl/materials_2006.html.

4. SSL Commercialization Support Activities

On the third day of the DOE SSL workshop, presenters provided updates on the DOE five-year commercialization support plan, the 2006 Lighting for Tomorrow design competition, proposed ENERGY STAR criteria for SSL products, and NEMA SSL section activities to support standards development. The workshop concluded with a presentation from a lighting designer, who offered insights about what users want from SSL. To download the presentations detailed in this section, visit the Publications section of the DOE SSL website at: http://www.netl.doe.gov/ssl/materials_2006.html.

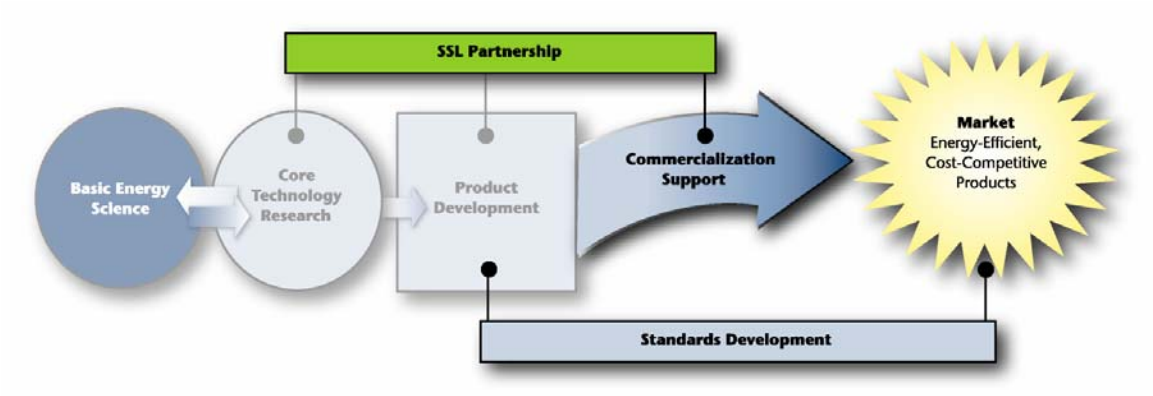

Figure 4-1: Day 3 Focus – SSL Commercialization Support Activities

4.1. DOE Solid-State Lighting Commercialization Support Overview

Marc Ledbetter, Pacific Northwest National Laboratory

Marc Ledbetter of Pacific Northwest National Laboratory provided an overview of DOE's five-year commercialization support plan. He emphasized that DOE is committed to supporting SSL in the long term, and commercialization support increases likelihood that these investments will pay off in big ways – 1.5 quads and $25 billion cumulative savings by 2025. The unique attributes of SSL technologies will likely trigger fundamental changes in the lighting market, sparking innovations that change the way lighting is delivered to the market. Commercialization support activities must be closely coordinated with research progress, to ensure appropriate applications of SSL product, and avoid buyer dissatisfaction and delay of market development. Ledbetter emphasized that DOE places high value on coordinating its commercialization support with NGLIA. The Alliance reviews and contributes to DOE plans and activities.

Ledbetter also described the need to act now, rather than waiting until the technology is more mature. While SSL is not currently appropriate for most general lighting applications, it is appropriate for a small and growing number of niche applications. DOE's role is to help consumers, businesses, and government agencies differentiate good products and applications as early as possible. Helping to counter misinformation, a common problem in a new market, and communicating performance targets to industry will increase likelihood of favorable buyer experiences with early generation LED products.

Several SSL commercialization support activities are currently under way. A CFL lessons-learned study will review and analyze the introduction of CFLs to determine what went right and what went wrong. A task force is working on the development of the DOE ENERGY STAR criteria for SSL products (see section 4.3 for more information). Ledbetter also described DOE efforts to inform and assist the standards development process, to encourage dialogue and coordination between all key organizations (see section 5.0). DOE is sponsoring design competitions, such as Lighting for Tomorrow (see section 4.2); conducting government agency and program coordination and outreach; and providing technical information to consumers, businesses, and government.

In addition, there are a number of comprehensive SSL commercialization activities pending, including technology procurements; demonstrations; tracking and information services; utility promotion and incentive programs; and information programs for retailers, builders, lighting designers, and students. See Appendix B for an overview of the DOE Solid-State Lighting Program Commercialization Support Pathway.

4.2. 2006 Lighting For Tomorrow Design Competition

Kelly Gordon, Pacific Northwest National Laboratory

Kelly Gordon of Pacific Northwest National Laboratory announced the 2006 Lighting for Tomorrow program, which includes a new solid-state lighting competition. The contest is organized by the American Lighting Association, the Consortium for Energy Efficiency, and DOE. The objectives are to encourage and recognize attractive, energy-efficient residential lighting fixtures; to build demand for energy-efficient lighting by demonstrating that it can be highly attractive and functional; and to encourage technical innovation in energy-efficient lighting.

Lighting for Tomorrow was started in 2002 to recognize and encourage attractive, energy-efficient decorative residential light fixtures. Lighting fixture designs are evaluated on the basis of energy efficiency, technical innovation, lighting quality, and aesthetic appeal. Past manufacturer participants include: Lithonia, Lightolier, Kichler, Progress Lighting, American Fluorescent, Justice Design Group, Fire & Water, Designers Fountain, and Good Earth Lighting.

In 2006, Lighting for Tomorrow is launching a new SSL competition. Goals include exploring the use of white-light LEDs in niche applications, evaluating fixtures employing SSL, facilitating learning by the lighting fixture industry, and advocating high-quality, energy-efficient use of SSL.

Submissions will be judged by a panel of LED experts, lighting retailers, homebuilders, lighting designers, and members of the lighting trade press, who will provide valuable feedback to entrants. The contest will also provide input to the ENERGY STAR and utility energy efficiency programs nationwide, and increase knowledge among traditional lighting fixture manufacturers, building future demand for SSL.

For more information, including rules, entry requirements, and deadlines, visit: www.lightingfortomorrow.com.

4.3. ENERGY STAR Update

Jeff McCullough, Pacific Northwest National Laboratory

Jeff McCullough of Pacific Northwest National Laboratory provided participants with an update on the development of the DOE ENERGY STAR criteria for SSL products. The proposed ENERGY STAR criteria will focus initially on LEDs, and exclude OLEDs for now. Coverage is limited to general illumination only, and excludes hybrid fixtures. It addresses both residential and commercial applications, with CCTs limited to 2700–6500K. The criteria will address system based efficacy (includes driver losses) and will adopt the L_{70} definition for rated life.

McCullough outlined DOE's vision for the proposed ENERGY STAR format, which includes two categories: near-term niche applications (Category A), and efficacy-based performance (Category B). In the future, when there are a large number of systems meeting Category B, Category A will be dropped.

Proposed Category A products have low to moderate illuminance requirements, and address tasks a modest distance from the light source. These near-term niche products include under-cabinet kitchen lighting, under-cabinet desk/task lighting, display case lighting, portable desk lamps, outdoor step lighting, outdoor walkway lighting, and outdoor porch lighting.

Category B products address efficacy-based or efficiency performance, similar to other ENERGY STAR criteria. Long-term efficacy targets will be based on how well the product exceeds CFL thresholds (50-70 lm/W), and exceeds levels achievable within the next 3-5 years. The level will be set by balancing the need for an aggressive target and the impact on system cost.

The development of standards and test procedures is important to this ENERGY STAR effort. Many standards for SSL products do not exist or are in development. McCullough announced DOE plans to host a workshop in early March for key standards organizations, including the Illuminating Engineering Society of North America (IESNA), National Institute of Standards and Technology (NIST), National Electrical Manufacturers Association (NEMA), American National Standards Institute (ANSI), Underwriters Laboratories (UL), International Electrotechnical Commission (IEC), International Commission on Illumination (CIE), and Canadian Standards Association (CSA). Note: This workshop took place on March 1, 2006, and provided a forum for greater cooperation and collaboration among these organizations (see Section 5.0 for more details).

For more information on the initial DOE ENERGY STAR criteria, including a proposed schedule, download the complete ENERGY STAR Update presentation at: http://www.netl.doe.gov/ssl/PDFs/ENERGY%20STAR%20SSL%20Workshop.pdf.

4.4. NEMA SSL Section Update

M. "Chips" Chipalkatti, NEMA SSL Section

M. "Chips" Chipalkatti spoke on behalf of NEMA's Solid-State Lighting Section, which is tasked with integrating solid-state light sources with existing lighting practices and the creation of new practices to fully exploit the technology's potential. The SSL Section encompasses both products and technologies, and is working jointly with other NEMA Sections on aspects which pertain to the unique requirements of SSL devices.

A strategic task force has been created to look at the NEMA SSL vision and roadmap, and define specific near-term tasks. A technical task force is working to address technical ambiguities and to develop working guidelines in the short term, as standards organizations continue their work.

SSL drivers are efficacy, including power (W) and light (lumens); functionality (applications); quality (color, light, distribution); and cost (capital cost and ownership cost). Standards are needed to define these measures, and efforts are under way, starting with a glossary of terms. Some important solid-state lighting terms are still somewhat ambiguous and need to be defined before basic standards can be written. A working draft glossary was turned over to the newly formed ANSI Working Groups for solid-state lighting, for review and further refinement. A matrix of standards impacting solid-state lighting products has been developed to provide a roadmap of tasks to complete, facilitate collaboration with other standards organizations, and eliminate duplication.

The Solid-State Lighting Section is also working with Underwriters Laboratories Inc. on the consolidation of safety standards pertaining to LEDs, and collaborating with IESNA on performance standards to develop a useful color characterization metric that will include LEDs. In addition, the SSL Section supports DOE ENERGY STAR activities through the NGLIA ENERGY STAR Task Group, and is working to address requirements for market success, including development of appropriate infrastructure. Next, the Section will focus on deployment and linking the technology to the infrastructure. For more information on NEMA's SSL Section activities, see: http://www.nema.org/prod/lighting/solid/.

4.5. Technology & Art – A Designer's Perspective

Ted Ferreira, City Design Group

Ted Ferreira, City Design Group, presented a designer's perspective of the SSL market. City Design is a lighting consulting firm with offices in four cities, advising clients on $150 million worth of commercial lighting applications in 2005. Ferreira noted that just as many see architecture as art, participants need to also look at lighting as an art form, stating, "If it's unattractive, it has missed the mark."

Ferreira described some recent experiences integrating SSL elements into his projects. From a design perspective, SSL has come a long way in terms of color consistency, fixture design/manufacturing, signal stability/firmware, and brightness. But those in a position to select lighting are mostly focused on problem-solving, and like it or not, aesthetics override nearly all other considerations in design. From the commercial customers' perspective, Ferreira stressed that they want quantitative standards, warranty guarantees, dependable packaging, specification support, defined pricing, and most of all, a chance to be heard.

Ferreira stated his belief that the residential market is 20 years away. For the commercial market at the heart of his business, he said that clients need a product that solves a problem, works well, and is installed by a trained professional. He emphasized that customer service will drive the success of SSL over time. As for the market, drivers should include regulation, technological curiosity, operational savings, and decorative desires.

For lighting designers, aesthetics override nearly all other considerations. Ferreira presented a sample light and called it "aesthetically unacceptable" because of its glare, his emphasis placed on the light rather than the illuminated subject or area in the room. "I need a light that works, installed by a trained person—it's not about luminous efficacy for me."

5. Next Steps

Moving forward, the Department of Energy will continue to work closely with the Alliance, the SSL R&D community, energy efficiency organizations, and standards generating organizations to speed energy-efficient SSL technologies from the laboratory to the marketplace.

In March 2006, the Department announced competitive selections for Core Technology Research (Round 2) projects. Selections for Product Development (Round 2) projects will follow in Spring 2006. The Round 2 solicitations were released in 2005.

In Spring 2006, DOE will announce another round of Core Technology and Product Development competitive solicitations (Round 3), with awards to be made in FY 2007. The Department will also announce an SSL Nanoscience Technology solicitation in Spring 2006.

A Commercialization Support Activities solicitation will be issued in Summer 2006, for testing and evaluation of SSL products, development of test procedures, and other commercialization support activities. In September, DOE's Small Business Innovation Research (SBIR) Program will issue its annual solicitation, which includes topics related to solid-state lighting. To register for ongoing updates related to DOE SSL solicitations, see: http://www.netl.doe.gov/ssl/.

The DOE SSL website provides regular updates related to the Department's commercialization support activities and progress as well. On March 1, 2006, DOE hosted an LED Standards Industry Workshop to provide a forum for greater cooperation and coordination among standards organizations. The Department presented details of the proposed DOE ENERGY STAR criteria for SSL products, which will be made public later this year. Representatives from the major standards generating organizations, including the American National Standards Institute (ANSI), Illuminating Engineering Society of North America (IESNA), National Electrical Manufacturers Association (NEMA), National Institute of Standards and Technology (NIST), Underwriters Laboratories (UL), International Electrotechnical Commission (IEC), International Commission on Illumination (CIE), and Canadian Standards Association (CSA), provided overviews of their current activities related to LEDs.

The collective group identified key LED technology characteristics requiring standards and test procedures, and assigned the appropriate standards organizations to lead the development in each area. DOE will work with these organizations to align their individual priorities and schedules, and maintain a master roadmap of development activities. With DOE support and leadership, the group will continue to coordinate, update progress, and accelerate the development process.

The development of standards and test procedures is critical to the DOE ENERGY STAR criteria development process. The proposed schedule for ENERGY STAR criteria includes development of draft specifications for industry review and comment by July

2006, and a stakeholder meeting that same month. Following a three month public review and comment period, final criteria will be issued in October 2006.

Another priority for 2006 involves the Lighting for Tomorrow Design Competition, which will include a solid-state lighting competition for the first time. For more information on entry requirements and deadlines, visit: www.lightingfortomorrow.com.

Planning is already under way for the 2007 DOE Solid-State Lighting Workshop, scheduled for early February 2007. Register for updates at: http://www.netl.doe.gov/ssl/.

The Department will continue to coordinate with the Alliance, the SSL R&D community, energy efficiency organizations, and standards generating organizations to accelerate market introduction of energy-efficient SSL products that can compete in the general illumination market and deliver significant energy savings.

6. Appendices

Appendix A: SSL R&D Workshop Registrants List
Appendix B: DOE Solid-State Lighting Program Commercialization Support Pathway

APPENDIX A: SSL R&D Workshop Registrants List

Registrant's Name	Company
Srinath Aanegola	GELcore LLC.
Paul Alivisatos	University of CA/Berkeley
Alan Allan	Intel Corporation
Diane Allard	Akoya/DOE
Stephen Allison	Oak Ridge National Lab
Daniel Barton	Sandia National Laboratories
David Bay	OSRAM SYLVANIA Development Inc.
Rolf Bergman	Rolf Bergman Consulting
Jerry Bernholc	NC State University
Michael Bowers	Vanderbilt University
Paul Braun	University of Illinois at Urbana-Champaign
James Brodrick	US Department of Energy
Joe Brooks	Nye Lubricants, Inc.
Steven Brueck	University of New Mexico
Eric Bruton	Crosslink
Anthony Burrell	Los Alamos National Lab
Paul Burrows	Pacific Northwest National Laboratory
Densen Cao	CAO Group, Inc.
Elizabeth Cecchetti	Pacific Northwest National Laboratory
Joel Chaddock	US DOE - NETL
David Cheever	Articulated Technologies
James Chelikowsky	University of Texas at Austin
Jian Chen	Nanosys Inc.
M. "Chips" Chipalkatti	OSRAM SYLVANIA INC
Ed Christy	National Energy Technology Laboratory
Mike Coltrin	Sandia National Labs
Mary Colvin	National Renewable Energy Laboratory
Wayne Cooke	Los Alamos National Laboratory
George Craford	Lumileds
J. Randall Creighton	Sandia National Laboratories
Brian Crone	Los Alamos National Lab
John Curran	Dialight Corporation
Brian D'Andrade	Universal Display Corp.
Wendy Davis	NIST
Kevin Dowling	Color Kinetics
Anil Duggal	General Electric
Russell Dupuis	Georgia Institute of Technology
Ryan Egidi	NETL
Waqidi Falicoff	Light Prescriptions Innovators
Zhaoyang Fan	Kansas State University
Alfred Felder	OSRAM OPTO
Ian Ferguson	Georgia Tech - ECE
John Ferraris	University of Texas at Dallas

Registrant's Name	Company
Ted Ferreira	City Design Group
Arthur Fischer	Sandia National Labs
Tim Fitzsimmons	U.S. Department of Energy
Stephen Forrest	University of Michigan
Jean Frechet	Lawrence Berkeley National Laboratory
Douglas Freitag	Dow Corning
Jim Gaines	Philips
Giulia Galli	University of California, Davis
Leo Geng	CAO Group, Inc.
Ken Gertz	Rensselaer Poltechnic Institute
Kelly Gordon	Pacific Northwest National Laboratory
Kevin Gray	Saint-Gobain High Performance Materials
Drew Hanser	Kyma Technologies, Inc.
Uwe Happek	The University of Georgia
Maddie Harwood	SAGE Systems Technologies, LLC
Karsten Heuser	Osram Opto Semiconductors GmbH
Kai-Ming Ho	Ames Laboratory
Paul Holloway	University of Florida
Carolyn Holmes	3M
Michelle Huang	OSRAM Opto Semiconductors, Inc
Mark Huey	Strategic Perspectives, Inc
Jaehyung Hwang	Princeton University
James Ibbetson	Cree SBTC
James Intrater	Materials Modification, Inc.
Jack Ivey	Altair Engineering
Luiz Jacobsohn	Los Alamos National Laboratory
John Joannopoulos	MIT
Antoine Kahn	Princeton University
Shawn Keeney	Dialight
John Kerr	Lawrence Berkeley National Laboratory
Aravinda Kini	DOE
Glenn Kohnke	Corning Incorporated
Sandy Kushner	Air Products & Chemicals, Inc.
Susan Larson	iLight Technologies Inc.
Pierrette Leblanc	Natural Resources Canada
Marc Ledbetter	Pacific NW National Laboratory
Jae-Hwang Lee	Iowa State University
Stephen Lee	Sandia National Laboratories
Kewen Li	Boston Applied Technologies, Inc.
Shawn Yu Lin	Rensselaer Polytechnic Institute
Gao Liu	Lawrence Berkeley Lab
Jie Liu	Duke University
George Malliaras	Cornell University
Samuel Mao	Lawrence Berkeley National Laboratory

Registrant's Name	Company
Karen Marchese	Akoya
James McBride	Vanderbilt University
Jeff McCullough	PNNL
Michael McGehee	Stanford University
Terry McGowan	American Ltg. Assoc.
John Mckinness	Leotek Electronics USA Corp.
Eugene Mele	University of Pennsylvania
Hisham Menkara	PhosphorTech
Alexander Mikhailovsky	University of CA Santa Barbara
Kailash Mishra	OSRAM SYLVANIA
Ley Mitchell	Cree, Inc.
David Mosley	Rohm and Haas Company
Theodore Moustakas	Boston University
Ross Muenchausen	LANL
Nadarajah Narendran	Rensselaer Polytechnic Institute
Jeff Nause	Cermet, Inc.
Ann Norris	Dow Corning Corporation
David Norton	University of Florida
Joseph Nowik	Radionic Industries, Inc.
Arto Nurmikko	Brown University
Michael O'Keefe	U.S. Department of Energy
Tim OBrien	Plextronics, Inc
Yoshi Ohno	NIST
Satoshi Okamoto	Department of Physics, Columbia University
Brett Parker	Heatron, Inc
Morgan Pattison	NETL
David Pelka	Tailored Optical Systems Inc.
Edward Petrow	Lincoln Technical Services, Inc.
Robert Pinnel	U S Display Consortium
Kyle Pitsor	NEMA
Jeff Popielarczyk	GE Global Research
Arthur Ramirez	Bell Labs Lucent Technologies
Ron Randall	CAO Group, Inc.
Ken Richardson	Instrument Systems
Kurt Riesenberg	NEMA
Spilios Riyopoulos	SAIC
Sandra Rosenthal	Vanderbilt University
Thomas Russell	University of Massachusetts
Linda Sapochak	Pacific Northwest National Laboratory
Holger Schwab	Philips Lighting
Rachel Segalman	UC Berkeley
Anant Setlur	GE
Joseph Shiang	General Elelctric
Joseph Shinar	Ames Lab/Iowa State Univ

Registrant's Name	Company
Anatoly Shteynberg	SynDiTec Inc.
Jerry Simmons	Sandia National Labs
Darryl Smith	Los Alamos National Laboratory
Franky So	University of Florida
Sameer Sodhi	Osram Sylvania
Christof Sommerhalter	AIXTRON Inc.
Christopher Somogyi	AES, Inc
Dr. Jin Joo Song	University of California, San Diego
Costas Soukoulis	Ames Laboratory
Ed Southwell	Perspectives
G. Brian Stephenson	Argonne National Laboratory
Matthew Stough	OSRAM SYLVANIA
Gerald Stringfellow	University of Utah
David Strip	Sandia National Labs
Christopher Summers	PhosphorTech
Jan Talbot	University of CA, San Diego
Mark Thompson	Univ. Southern California
Paul Thurk	ARCH Venture Partners
Andrew Timmerman	Fairfield Crystal Technology
Laren Tolbert	Georgia Institute of Technology
Yuan-Sheng Tyan	Eastman Kodak
Alexander Usikov	Technologies and Devices International
Valy Vardeny	Un. of Utah
Paul Vrabel	ICF Consulting
King Wang	Agiltron, Inc.
Shaoping Wang	Fairfield Crystal Technology
Wm. Ken Weidner	Dow Corning Corporation
Allen Weiss	SESCO lighting
Fred Welsh	Radcliffe Advisors
Christian Wetzel	Rensselaer Poytechnic Institute
Darryl Williams	Cabot Superior MicroPowders
Allison Winton	Radionic Industries, Inc.
Ed Wisniewski	CEE
Dale Work	Philips Electronics
Jun Xu	Oak Ridge National Laboratory
Ting Xu	University of Pennsylvania, CNBT at NIST
Jiangeng Xue	University of Florida
Cheng-Hsin Yuan	Cree, Inc.
Steffen Zahn	Air Products & Chemicals, Inc.
Anvar Zakhidov	University of Texas at Dallas
Shengbai Zhang	National Renewable Energy Laboratory
Theodore Zhou	Universal Display Corporation
Alex Zunger	NREL

APPENDIX B: DOE Solid-State Lighting Program Commercialization Support Pathway

Solid State Lighting Program

Commercialization Support Pathway

U.S. Department of Energy

UPDATE -- February 2006

Building Technologies Program
Energy Efficiency and Renewable Energy
U.S. Department of Energy

I. SSL R&D Investment Leads to Technology Commercialization

The U.S. Department of Energy has made a long-term commitment to develop and support commercialization of solid state lighting (SSL) for general illumination, including sources, fixtures, electronics, and controls. In August 2005, President Bush signed the Energy Policy Act of 2005 (EPACT 2005), the first national energy plan in more than a decade. Title IX (Research and Development) of the Energy Act directs the Secretary of Energy to carry out a Next Generation Lighting Initiative (NGLI) to support research, development, demonstration, and commercial application activities for SSL.

The Secretary is also directed to carry out research, development, demonstration, and commercial application activities through competitively selected awards. The Energy Act authorizes $50 million to the NGLI for each fiscal year 2007 through 2009, with extended authorization to allocate $50 million for each of the fiscal years 2010 to 2013. The actual Congressional appropriation for the NGLI will not be determined until fiscal year 2007.

This public R&D investment serves the ultimate goal to successfully commercialize the technologies in the buildings sector, where lighting accounts for more than 20 percent of total electricity use.

Potential benefits are enormous if SSL technology achieves projected price and performance levels:

- By 2025, SSL could displace general illumination light sources such as incandescent and fluorescent lamps, decreasing national energy consumption for lighting by about 0.45 quads annually, that is, enough energy saved to serve the lighting demand of 20 million households today.
- The cumulative energy expenditure savings from 2005 to 2025 would translate into more than $25 billion dollars saved.
- The cumulative energy savings from 2005 to 2025 is projected to be more than 1.5 quads.

To realize the full promise of solid-state lighting by 2025, major research challenges must be addressed. To help tackle these challenges, DOE is funding selected R&D to improve energy efficiency and speed SSL technologies to market. Projects are selected to align with a comprehensive R&D plan developed in partnership with industry, research and academic organizations, and national laboratories. DOE has and will continue to maintain a focus on the ultimate goal of supporting commercialization of SSL technologies to decrease lighting energy use while improving and expanding lighting services. Unique attributes of SSL technologies underscore the importance of a long-term, coordinated approach encompassing applied research and strategic technology commercialization support.

Effective market introduction of SSL technologies must be informed by and coordinated with the applied research currently underway. As R&D progresses, SSL technologies will attain performance levels that make them appropriate and advantageous for various

applications. For example, the energy efficiency and longevity of monochromatic LEDs now make them the obvious choice for traffic signals, exit signs, airport taxi-way lighting, and many other niche applications. As a result of extensive R&D, white-light LEDs have recently attained performance levels that begin to make them appropriate for use in automobiles, aircraft interiors, and some display applications. For most general illumination applications, current white LEDs cannot yet compete with traditional light sources on the basis of either performance or cost, but the technology is evolving rapidly. The timing and targeting of commercialization support efforts is as important to the ultimate success of SSL as current R&D investment. For this reason, DOE has created a comprehensive commercialization support plan, drawing on a variety of strategies to assist the market introduction of high-quality, energy-efficient SSL technologies.

II. Commercialization Support Strategies

DOE has a long-term vision for commercialization support of SSL technologies. Over the coming years, SSL technologies for general illumination will continue to improve and evolve, with luminous efficacy increasing and unit costs decreasing. Appropriate commercialization support strategies will be determined by the status of the technology relative to particular applications. Beginning in 2005, DOE initiated several activities as part of the long-term plan.

A. Activities in Progress

Partnership with Industry

EPACT 2005 directs DOE to partner, through a competitive selection process, with an Industry Alliance that represents U.S. SSL research, development, infrastructure, and manufacturing expertise. DOE is directed to solicit Alliance assistance in identifying SSL technology needs, assessing the progress of research activities, and updating SSL technology roadmaps. In fulfillment of this directive, DOE signed a Memorandum of Agreement with the Next Generation Lighting Industry Alliance (NGLIA) in 2005. Alliance members include the major US-based manufacturers of LEDs, OLEDs, components, materials, and systems.

ENERGY STAR for SSL

DOE has initiated development of ENERGY STAR criteria for white LED-based lighting products. DOE envisions a two-category criteria, with the first category (Category A) covering a limited number of general illumination niche applications for which white LED systems are appropriate in the near-term, and the second category (Category B) intended to cover a wide range of LED systems for general illumination. Category B will serve as the longer term target for the industry. Initial applications eligible under Category A will include those with the following characteristics: 1) appropriate for a light source with a directional beam, as opposed to a diffuse source; 2) low to moderate illuminance requirement; 3) illuminated task or surface relatively close to the light source; and 4) potential for cost-effective use of LED-based products in the near term.

Support for Standards Development
Solid state lighting differs fundamentally from incandescent, fluorescent, and HID lighting technologies. The materials, drivers, system architecture, controls, and photometric properties of SSL differ from traditional lighting technologies. A host of new test procedures and industry standards is needed to accommodate these technical differences. DOE is engaged in ongoing dialogue with the relevant standards organizations, and has offered technical assistance in the development of new standards.

Design Competition
DOE is one of the organizing sponsors of Lighting for Tomorrow (LFT), along with the American Lighting Association and the Consortium for Energy Efficiency. LFT design competitions in 2004 and 2005 were successful in encouraging, recognizing, and publicizing excellent new designs for energy-efficient residential decorative light fixtures. In 2006, LFT is introducing a new competition for LED products in specific niche applications. Working prototype fixtures will be evaluated by an expert judging panel which will select winners on the basis of lighting quality, energy efficiency, fixture design, and style.

Outreach to Federal Programs
As the largest single purchaser of lighting products in the nation, the federal government can play an important role in demonstrating new technologies. Recently, DOE has made provided information to more than 30 federal agencies through presentations to the Federal Utility Partnership Working Group, the Interagency Energy Management Task Force, and the Federal Energy Efficiency Working Group.

Technology Tracking and Information Services
DOE continues to track performance improvement in LED and OLED technology over time. DOE also maintains a database of available white LED-based niche lighting products available in the market. This information is used not to publicize individual products, but to provide general information about pricing and availability trends of LED products.

Consumer and Business Awareness Programs
DOE has developed informational materials on LED technology and products for a general consumer and business audience. A two-page fact sheet covering basic technical issues related to LEDs was disseminated at GreenBuild, the National Weatherization Training Conference, Energy 2005, and other events. Additional information of use to consumers and businesses is available online via DOE's SSL website at www.netl.doe.gov/ssl/.

Utility Promotion and Incentive Programs
Through ongoing communication with the Consortium for Energy Efficiency, which represents utilities, state energy offices, and regional energy efficiency organizations, DOE provides information and seeks feedback from the utility/energy efficiency sector on commercialization of SSL technologies.

B. Planned Activities

In addition to the activities already underway, DOE is planning a range of other initiatives that will support commercialization of SSL technologies and products. These include the following:

Technology Procurement
Technology procurement is an established process for encouraging market introduction of new products that meet certain performance criteria. DOE has employed this approach successfully with other lighting technologies, including sub-CFLs and reflector CFLs. DOE plans to employ technology procurement to encourage new SSL systems and products that meet established energy efficiency and performance criteria, and link these products to volume buyers and market influencers. Volume buyers may include the federal government (FEMP, DLA, GSA), utilities, or various sub-sectors including hospitals, lodging, or retail.

Demonstration and Performance Verification
DOE will gain real-life experience and data involving SSL installations in various applications through demonstration and performance verification, including measurement of energy consumption, light output, color consistency, and interface/control issues.

Retailer Training Programs
DOE will develop information and training materials to aid lighting retailers in communicating about SSL technologies with their customers.

Builder Programs
DOE will develop and deliver technology transfer and training programs to increase homebuilders' awareness and technical knowledge of SSL.

Designer Programs
DOE will support development of materials and curricula for interior design and lighting design professionals.

Education Programs
To support development of the next generation of engineers and designers who will implement SSL, DOE will support development of materials and information on SSL technologies for schools, supporting SSL-related projects in the context of class work and science fairs.

February 2006